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Report #
RRTAC 93 - 14

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LAND RECLAMATION:
AGRICULTURAL CAPABILITY CLASSIFICATION
FIELD MANUAL

Heritage Fund

Alberta
CONSERVATION AND
RECLAMATION COUNCIL
Reclamation Research
Technical Advisory Committee

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LAND RECLAMATION:
AGRICULTURAL CAPABILITY CLASSIFICATION
FIELD MANUAL

by

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Prepared for

Alberta Conservation and Reclamation Council
Reclamation Research Technical Advisory Committee
1993

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PREFACE

The goal of land reclamation in Alberta is to create land capability equivalent to that which existed prior to the disturbance. A primary requirement is to salvage all topsoil prior to disturbance and to replace it during the reclamation process. Topsoil is defined as the uppermost mineral and organic soil materials which are valued as a growth medium. It includes the A horizon (Ah, Ahe, Ap, optional Ae), and peat or organic litter (O and LFH horizons) to a depth of 50 cm. Other soil handling requirements are based on soil characteristics, landscape features, climate and present and potential land use. These requirements are planned and implemented on a project-specific basis.

Successful reclamation is dependent upon reconstructing favourable growing conditions in the one metre soil profile, with emphasis on the upper 50 cm. Key factors relating to the root zone quality that are used in this system include: water holding capacity, organic carbon content, structure and consistence, salinity, sodicity, soil reaction, nutrient imbalance, moisture regime and topsoil loss. The main landscape parameters include: slope, stoniness, pattern and erosion. Principal climatic factors are precipitation and temperature.

ACKNOWLEDGEMENTS

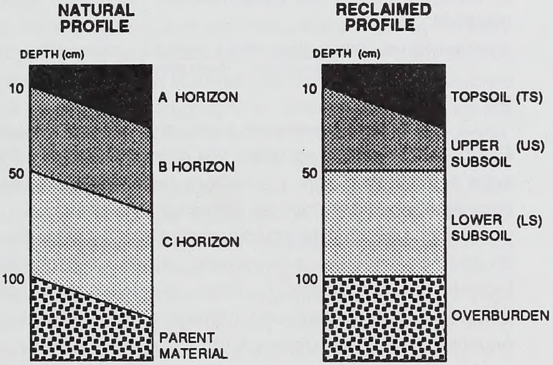
This project was sponsored by the Reclamation Research Technical Advisory Committee of the Alberta Land Conservation and Reclamation Council, with financial support from the Alberta Heritage Trust Fund, Land Reclamation Program.

Special thanks to the many reviewers, from Government and Industry, who provided very valuable input throughout the course of this project.

Computing facilities for preparation of the manual were provided by the Department of Entomology at the University of Alberta.

INTRODUCTION

This manual outlines the steps required in applying the "Land Reclamation: Agricultural Capability Classification" (Leskiw 1993). It applies to arable dryland agricultural conditions and can be used on natural and reclaimed lands. The emphasis is on soil and landscape ratings as tested in the field on reconstructed soils at coal mines, wellsites, sand and gravel pits, and pipelines. Horizon designations used in describing common types of profiles examined are illustrated below.



SOIL RATING

Rating of mineral soils is considered in four parts; topsoil or surface soil, upper subsoil (below topsoil to 50 cm), lower subsoil (50 to 100 cm), and moisture regime. The surface rating becomes the basic soil rating with subsurface factors and moisture factors used as modifiers. Factors in the basic rating are assessed by point deductions and the modifiers as percent deductions. The tables and figures following indicate point or percent deductions for various soil limitations.

In reclaimed agricultural lands the minimum thickness of the topsoil (Ah, Ahe, Ap, optional Ae) is 10 cm. The Ae should be salvaged if it maintains or improves soil quality. If topsoil is absent, then rate the upper 10, 15, or 20 cm, whichever depth matches the depth of cultivation on natural agricultural lands in the area.

Soil texture is used to estimate soil available water holding capacity in the 100 cm profile and points are deducted as indicated. A higher weighting is given to the upper 50 cm (70:30%), therefore, texture differences within the 100 cm must be accounted for using the following equation:

$$\text{AWHC (mm/100 cm)} = (70\% \times \underset{\text{upper 50 cm}}{\underline{\text{AWHC}}} + 30\% \times \underset{\text{lower 50 cm}}{\underline{\text{AWHC}}}) \quad \times \text{100 cm profile}$$

or

$$= [70\% \times \text{AWHC(In 0 - 50 cm)} + 30\% \text{ AWHC (In 50 - 100 cm)}] \times 2$$

Examples using this equation are included with the AWHC point deductions graph. Deductions for topsoil structure and consistence are assigned as tabulated.

Topsoil depth and organic carbon are combined based on horizon thickness and organic carbon content (graphs indicate the relationship between dry soil colour, horizon thickness, soil density and organic carbon mass). The equation used to calculate soil organic carbon mass is:

$$[\text{Tonnes OC/ha} = \text{OC\%} \times \text{depth (m)} \times \text{bulk density (T/m}^3) \times 10\,000 \text{ m}^2\text{/ha}]$$

In the evaluation of topsoil reaction, salinity, calcareousness, and sodicity and saturation percentage, lab analyses are desirable to calibrate field measurement techniques. Soil reaction can be measured with a field pH kit, calcareousness with dilute HCl, and salinity using vegetation indicators or a field salinity meter (such as EM-38). High saturation percentages sometimes occur in non-sodic (SAR 4 or less) topsoils with high organic content. Do not deduct points for "saturation %" in such instances. Also, if topsoil texture is coarser than loam, do not deduct SAR.

When making topsoil deductions, add moisture availability, organic carbon and only the most limiting of: structure, pH, salinity, sodicity, or nutrient imbalance. Peaty or organic topsoils are rated based on thickness, moisture availability - and the most limiting of structure, pH, salinity, sodicity or nutrient imbalance. A deduction for topsoil loss is assigned, where applicable.

Subsoil is divided into upper (below topsoil to 50 cm) and lower subsoil (50 to 100 cm). A relative rating of 2:1 or 67:33% respectively, is assigned to these layers in calculating the deduction for topsoil loss. Deductions are made for the most limiting of structure, acidity, salinity and sodicity/saturation%, regardless of the surface or topsoil condition. Deductions for soil structure, based on size of aggregates, and consistence are made in the field. Dropping a spade-full of soil 1 metre onto a hard surface is suggested as the standard for determining breakdown of a soil mass into aggregates. Then the aggregates are "hand picked" to determine the dominant size fraction. Soil reaction is measured with a field kit or in the lab and deductions are assigned as indicated. Subsoil deductions for salinity are based on lab analysis. Overall profile salinity could also be measured in the field with an EM-38. Only the most limiting of SAR or saturation percentage is deducted. If soil texture is coarser than loam, SAR deductions are not made. The same rating procedures are used for upper and lower subsoils and results are weighted as shown. If upper subsoil is <15 cm, rate only lower subsoil.

To evaluate wetness, the main factor to be considered is the uppermost level of the water table, which should be present for a minimum of one month during the growing season. In the absence of wetness, as in moderately well to very rapidly drained soils, the adjustment is based on climate droughtiness (P-PE Index). Apply only the smaller percentage as the multiplier, either excessive wetness or climatic factor.

SURFACE (TOPSOIL)

Moisture Availability Based on Texture: Subclass M

Texture	Total Available Moisture (mm) mm/cm	 0 to 100 cm
Gravel	0.2	20
Sand	0.4	40
Loamy sand	0.6	60
Sandy loam	1.0	100
Loam, sandy clay	1.5	150
Sandy clay loam	1.5	150
Clay loam	1.7	170
Silt loam, silt	1.8	180
Clay	1.9	190
Silty clay loam	2.0	200
Silty Clay	2.25	225
Heavy clay	2.25	225
Peat	1.5	150
Gravelly modifier (Deduct 0.1 mm/cm from texture or 10 points from 1 m)		
Peaty (Add 0.1 mm/cm to texture or 10 points to 1 m)		

Sample AWHC Calculations

1. **20 cm L / 80 cm CL**

= [0.7(20 cm L @ 1.5 mm/cm + 30 cm CL @ 1.7 mm/cm)
+ 0.3 (50 cm CL @ 1.7 mm/cm] x 2
= [0.7 (30 + 51) + 0.3(85)] x 2
= 164 mm (no deductions)

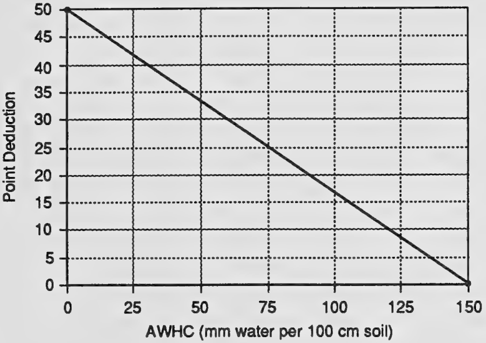
2. **30 cm SL / 70 cm CL**

= [0.7(30 cm SL @ 1.0 mm/cm + 20 cm CL @ 1.7 mm/cm)
+ 0.3(50 cm CL @ 1.7 mm/cm)] x 2
= [0.7(30 + 34) + 0.3 (85)] x 2
= 141 mm (a 2 point deduction)

3. **20 cm SL / 50 cm LS / 30 cm S**

= [0.7(20 cm SL @ 1.0 mm/cm + 30 cm LS @ 0.6 mm/cm)
+ 0.3(20 cm LS @ 0.6 mm/cm + 30 cm S @ 0.4 mm/cm)] x 2
= [0.7(20 mm + 18 mm) + 0.3(12 mm + 12mm)] x 2
= 68 mm (a 27 point deduction)

Deduction for AWHC



Topsoil Structure: Subclass D

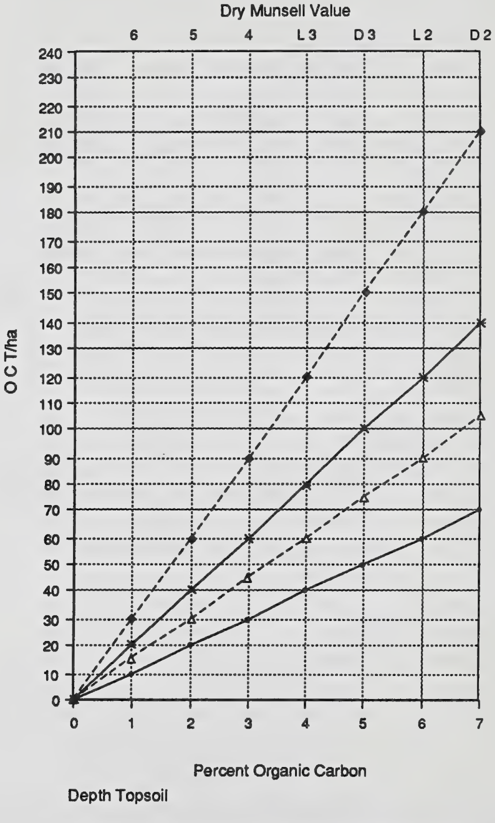
Structure[a]	Dominant Size peds/aggregates	Consistence[a] moist/dry	Points Deducted
granular	<5 mm	very friable/soft	0
granular, subangular	5 - 10 mm	friable/slightly hard	5
powdery, single grain	<2 mm	loose/loose	10
platy	<5 mm	hard or loose	
crusted surface	variable		
medium blocky [b]	10 - 20 mm	firm/hard	20
coarse blocky	20 - 100 mm	very firm/very hard	
cloddy			
massive	>100 mm	extremely firm/ extremely hard	30

[a] Deduct points based on the most limiting condition, either structure or consistence.

[b] Subsoil material at the surface is usually rated: 20 points for loam to clay loam, 30 points for clay.

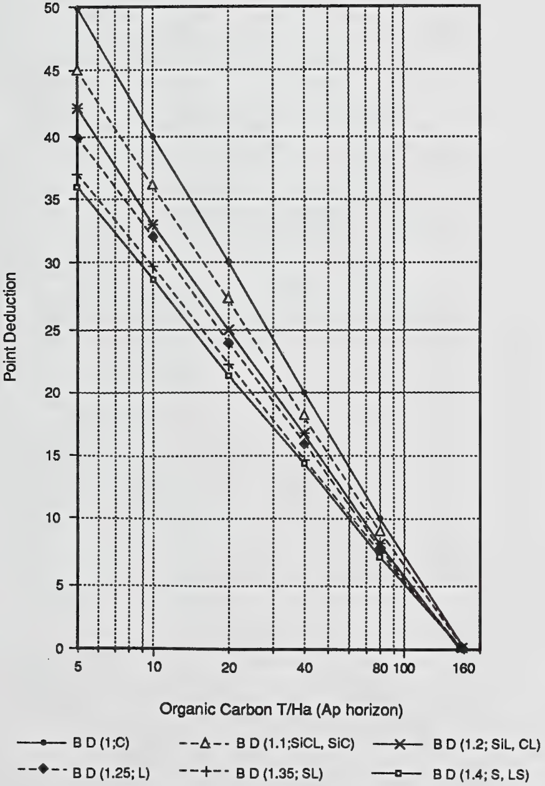
Organic Carbon and Topsoil Depth: Subclass F

Organic Carbon T/ha



L = light 'value' D = dark 'value'

Organic Carbon and Point Deduction



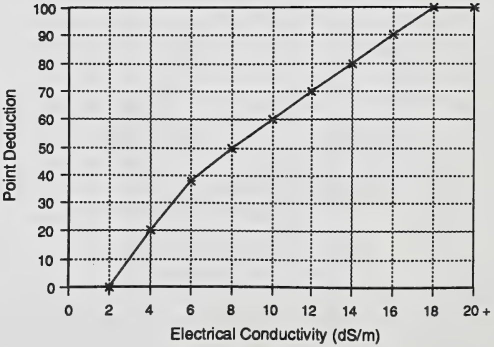
Topsoil Reaction: Subclass V

Soil pH[a]	Points deducted
9.0[b]	60
8.5	20
8.0	5
6.5-7.5	0
6.0	2
5.5	5
5.0	15
4.5	30
4.0	55
3.5	80

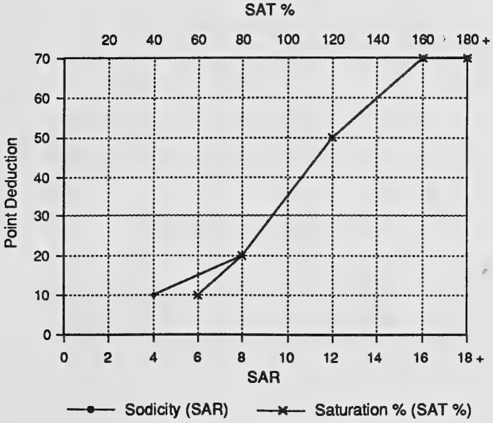
[a] Measured in saturated paste. Add 0.5 units to pH values measured in $CaCl_2$.

[b] Round off to nearest 0.5 units.

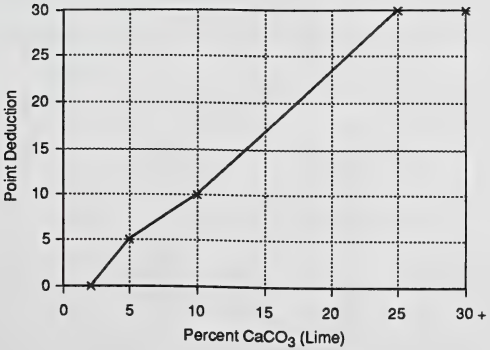
Topsoil Salinity: Subclass N



Topsoil Sodicity and Saturation %: Subclass Y



Topsoil Calcareousness: Subclass K



Organic (Peaty) Surface: Subclass O

Depth of Peat (cm)[a] non-compact	compact	Degree of decomposition	General structure	General consistence	Points deducted
10	10	humic			0
15	15	humic	compact	friable	5
20	15	mesic			5
25	15	fibric	spongy	fibrous	10
30	30	humic	compact	friable	10
40	30	mesic			15
50	30	fibric	spongy	fibrous	20

[a] Depths of <10 cm should be handled as mineral soils.

NOTE: When rating a peaty surface, the above ratings address physical handling or cultivation of the peat. Ratings for pH may differ from equivalent pH in mineral soils - nutrient deficiencies may occur, etc. Deductions for the latter should be documented and made under nutrient imbalance.

Topsoil Loss: Subclass G

During the grading process, either when stripping or replacing topsoils, there may be a significant loss of topsoil caused by insufficient removal, loss during storage, uneven replacement, mixing with subsoil or other reasons. A 5 point deduction is made for every 10 percent loss in thickness of topsoil, based on average control depth or a "specified" depth.

SUBSOIL

Subsoil Structure: Subclass D

Structure, aggregate size Consistence, moist/dry	Percent Deduction
Dominant soil aggregates <2 cm diameter. Very friable/soft or friable/slightly hard.	0
Dominant soil aggregates < 2 cm diameter. Firm/hard.	10
Dominant soil aggregates 2 to 10 cm diameter. Firm/hard.	20
Dominant soil aggregates 2 to 10 cm diameter. Very firm/very hard.	30
Sands, gravels, outwash deposits, loose materials.	30
Dominant soil aggregates 10 to 30 cm diameter. Very firm/very hard.	50
Soil is massive with aggregates >30 cm diameter. Extremely firm/extremely hard.	70
Consolidated material that is massive, >30 cm sized blocks. Extremely firm/extremely hard.	90

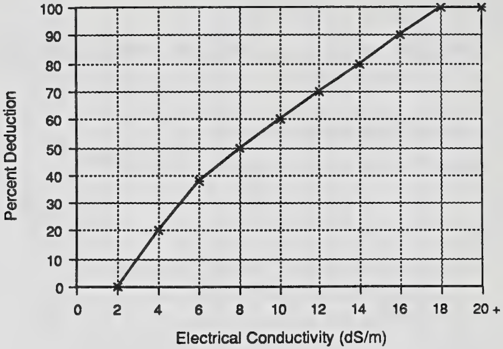
NOTE: For layered, bedded materials, or compacted materials that have firmer/harder consistence, rate the most limiting part of a layer. Rate the most limiting structure or consistence.

Subsoil Reaction: Subclass V

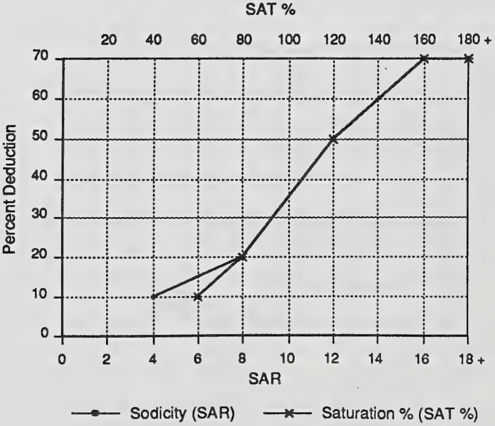
Subsoil pH[a]	Percent deduction
>6	0
6.0	0
5.5	2
5.0	5
4.5	15
4.0	30
3.5	55

[a] Round off pH to nearest 0.5 units.

Subsoil Salinity: Subclass N



Subsoil Sodicity and Saturation %: Subclass Y



SOIL MOISTURE REGIME

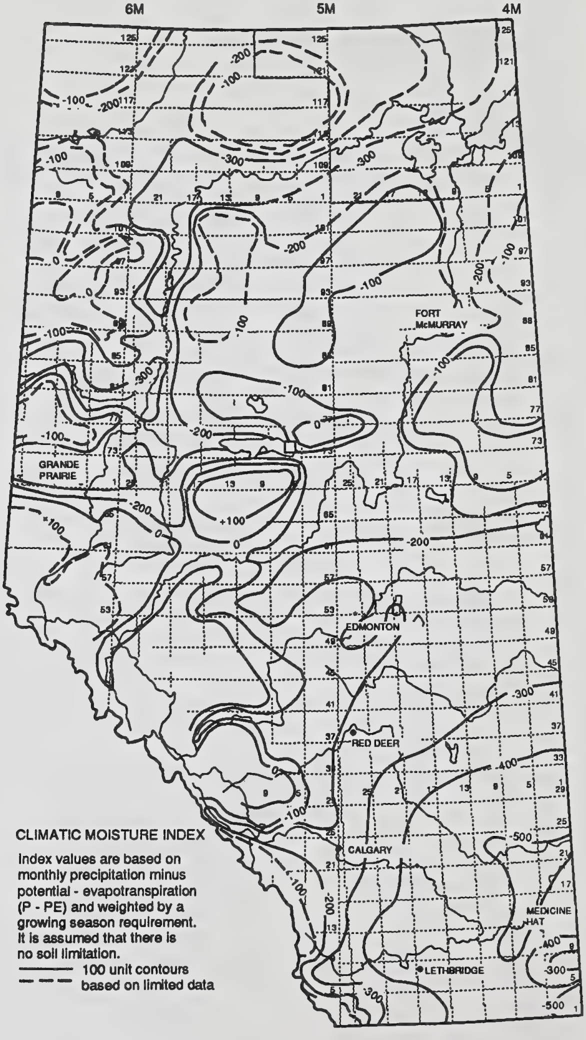
Soil Wetness: Subclass W

Wetness Category	Water Table Depth	Drainage Class	Soil/Vegetation	Adjustment Factor (%)
W0	> 2 m	moderately well to rapidly	normal	100
W1	1-2 m	moderately well	can cultivate 9 out of 10 years	90
W2	< 1 m	imperfectly	can cultivate 8 out of 10 years	80
W3	< 1 m	imperfectly	can cultivate 7 out of 10 years	70
W4	< 1 m	imperfectly	can cultivate 6 out of 10 years	60
W5	< 1 m	imperfectly	can cultivate 5 out of 10 years	50
W6	< 50 cm	poorly	sedges, willows; can cultivate < 5 out of 10 years	30
W7	surface for 1, 2, 3 months	very poorly	gleysolic soils sedges, sloughs	15
W8	surface for 4 months	very poorly	ponded water	10

Soil Moisture Adjustment Factors for Droughtiness.

Climate (A) P-PE Index[a]	Adjustment Factor (%)
-250	100
-300	95
-350	90
-400	85
-450	80
-500	75
-550	70
-600	65

[a] See map on page 14.

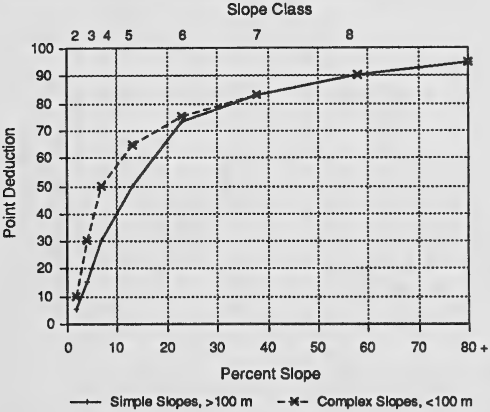

6M
5M
4M
FORT McMURRAY
GRANDE PRAIRIE
EDMONTON
RED DEER
CALGARY
MEDICINE HAT
LETHBRIDGE
-100
-200
-300
-400
-500
0
+100
CLIMATIC MOISTURE INDEX
Index values are based on monthly precipitation minus potential - evapotranspiration (P - PE) and weighted by a growing season requirement. It is assumed that there is no soil limitation.
100 unit contours
based on limited data

Alberta Climatic Moisture Index (P-PE)

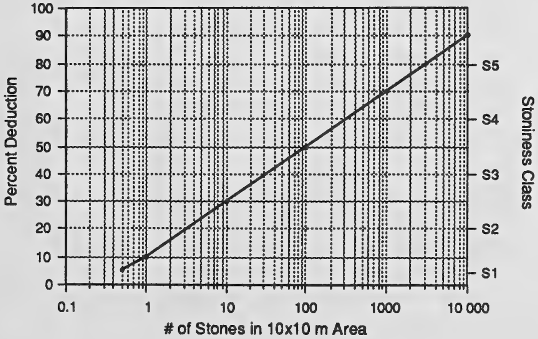
LANDSCAPE RATING

Topography determines the basic rating with stoniness, pattern and erosion as modifiers.

Slope Steepness and Length: Subclass T



Stoniness Factor: Subclass P



Landscape Pattern (Obstacles, Field Size): Subclass J

Make a 1% deduction for every slough (or other obstacle) per quarter section, to a maxumum of 20%. For field size: deduct 20% if field is <16 ha (40 acres) plus an additional 0.25% per obstacle.

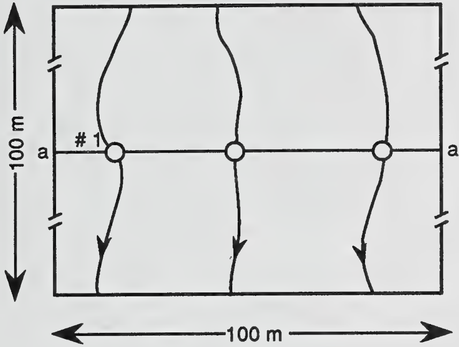
Erosion Factor: Subclass E

The erosion classes given on the following page reflect actual visible erosion. Determine the number of years since reclamation, estimate volume of soil loss by rill and gully erosion, calculate average annual loss, and assign the appropriate deduction. Assume average bulk density of 1.35 g/cm^3.

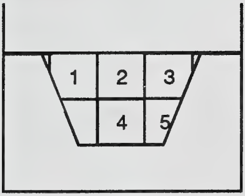
Soil Erosion Calculation

To estimate rill and gully erosion loss, select a representative 100 m x 100 m square (1 ha) on a slope; establish a transect (a - a') across the middle of the "hectare", along the contour (perpendicular to direction of rills and gullies); tally number of rills/gullies and cross-sectional area of each in square decimetres (that is, estimated number of 10 cm x 10 cm "frames" per cross-section of rill/gully); total number of these "frames" equals soil loss in cubic metres per ha, assuming 100 m length of rills/gullies (see diagram on next page). For instance, example #1, a rill 30 cm wide at the top, 20 cm wide at the bottom, and 20 cm deep has an approximate cross-sectional area of 5 "frames", each 10 x 10 cm. Such a rill that is 100 m long represents a soil loss of 5 m^3. If six such rills formed in one year, the annual soil loss would be 30 m^3/ha, which is a 40% deduction.

Erosion Example



Example # 1



≈ 5 "squares"
10 cm x 10 cm
@ 100 m length = 5 m^3/ha

Soil Erosion Categories

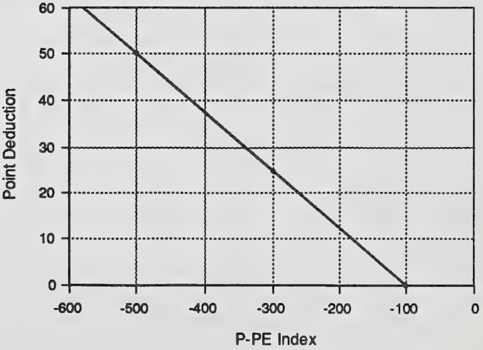
Percent Adjustment	Category	---Annual Soil Loss--- (weight)	(volume)
0	None	<6 tonnes/ha	<4.4 m^3
10	Slight	6 - <11 tonnes/ha	4.4 - <8 m^3
20	Moderate	11 - <22 tonnes/ha	8 - <16 m^3
30	Severe	22 - <33 tonnes/ha	16 - <24 m^3
40	Very severe	33 - <55 tonnes/ha	24 - <40 m^3
50	Extreme	≥55 tonnes/ha	≥40 m^3

CLIMATE RATING

Climate is an integral part of dryland agricultural capability in Alberta, so the indices developed reflect a concern for the common crops of the area and the summer growing season. The two principal variables determining climate capability are an energy factor and a moisture factor, the most limiting of which determines the climatic rating. In determining moisture and energy indexes from maps for specific areas, the user should interpolate the value to the nearest 50 units using the closest isolines.

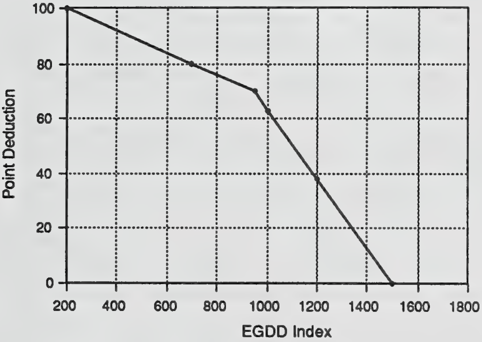
Moisture Component

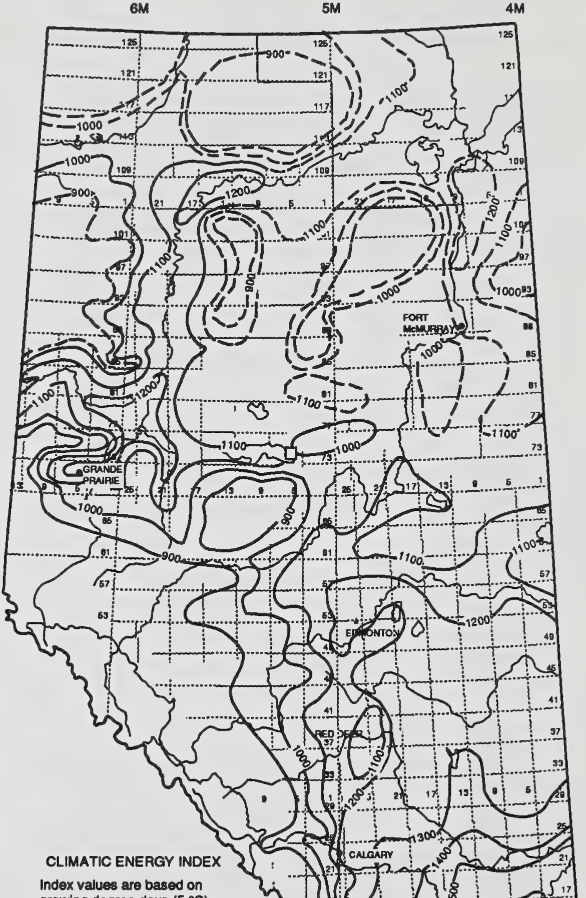
Point deduction for energy is determined from the following chart and the map of Climatic Moisture Index (page 14).



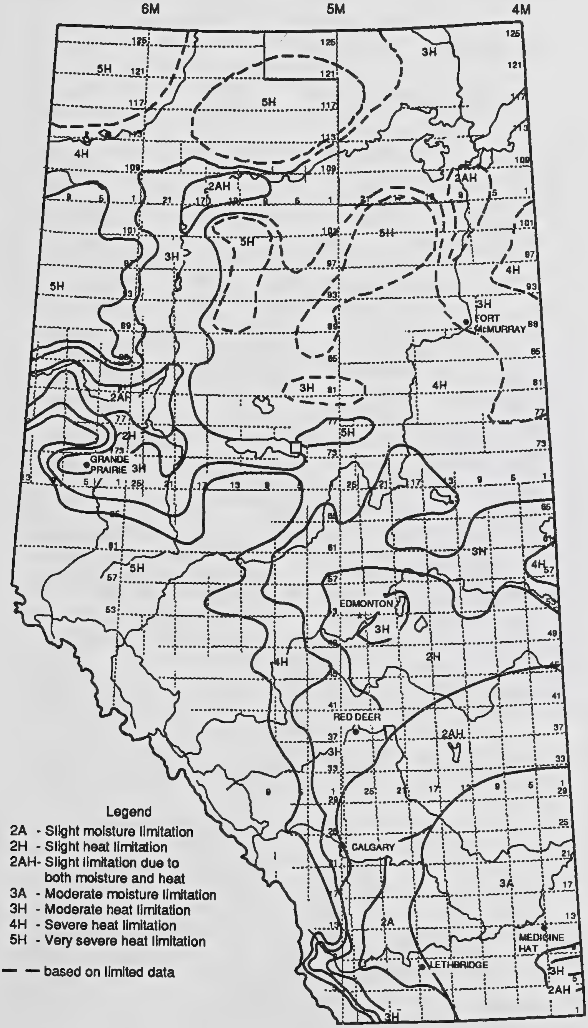
Energy Component

The energy component is based on an effective growing degree day (EGDD) calculation including length of season, degree days, day length and diurnal temperature range parameters. Point deductions for energy (heat or temperature) are shown in the following figure and based on the Alberta map on page 20. Agro-climatic classes for Alberta are shown page 21.





Alberta Climatic Energy Index


6M
5M
4M
5H
3H
4H
2AH
2H
3A
2A
FORT McMURRAY
GRANDE PRAIRIE
EDMONTON
RED DEER
CALGARY
MEDICINE HAT
LETHBRIDGE
Legend
2A - Slight moisture limitation
2H - Slight heat limitation
2AH- Slight limitation due to both moisture and heat
3A - Moderate moisture limitation
3H - Moderate heat limitation
4H - Severe heat limitation
5H - Very severe heat limitation
— — based on limited data

Generalized Agroclimatic Classes for Alberta

FORMS

Soil Description

Location/Site	
Map Unit/Soil Series	
Soil Classification	
Parent Material	Genetic Expression
Texture	Topsoil Subsoil
Drainage	R W MW I P VP
Wetness Category	W0 W1 W2 W3 W4 W5 W6 W7 W8
Topography	Percent Length m
Surface Stoniness	Gravel Stones
Pattern	No. obstacles / 1/4 Field size <16 ha ≥16 ha
Gully and Rill Erosion (visible)	None Sli Mod Sev V.Sev Ext
Land Use (at time of investigation)	Crop Hay Nat.Rge. Imp.Rge. Bush SF Other ___________
Crop/Sod Quality	Good Fair Poor
Compaction	None Sli Mod Sev V.Sev Ext
EXAMPLE PROFILE:	Samples

Horizon	Depth	Colour	Texture	Structure	Consistence

Comments:

Mineral Soil Rating

Location: ________ Surveyor: ________ Date: ________

1. Surface Factors	value	point deduction
- AWHC to 100 cm (M)		
- structure / consistence		
- organic carbon %		
and depth (F)		
- acidity (V) *		
- salinity (N) *		
- sodicity / saturation % (Y) *		
- nutrient imbalance (K) *		
- peaty surface (O) **		
- topsoil loss (G)		

* (deduct most limiting D, V, N, Y or K)

** (when deducting O, also deduct *)

Basic Soil Rating = 100 - ________ = (a) ________

2. Upper Subsoil Factors		% deduction
- structure (D) *		
- acidity (V) *		
- salinity (N) *		
- sodicity / saturation % *		

* (deduct one only, most limiting)

Upper subsoil deduction = ________ % of (a) x 0.67 = (b) ________

2. Lower Subsoil Factors		% deduction
- structure (D) *		
- acidity (V) *		
- salinity (N) *		
- sodicity / saturation % *		

* (deduct one only, most limiting)

Lower subsoil deduction ________ % of (a) x 0.33 = (c) ________

Interim Soil Rating = (a) ________ - (b) ________ - (c) ________ = (d) ________

4. Moisture Regime Factor (W)		Adjustment
- wetness *		
- climatic factor *		

* (deduct one only, smaller percentage)

Moisture Regime Adjustment = (W) ________ = (e) ________

FINAL SOIL RATING (S) = (d) ________ x (e) ________ = ________

= ________ Class , ________ Subclass

Landscape (L) Rating

1. Slope (T)	value	point deduction		
- slope steepness	________%			
- slope length	________m	________		
Basic Landscape Rating =	100 -	________	= (a)	________
2. Stoniness		% deduction		
- class	________	________		
Stoniness deduction =		________	% x (a) = (b)	________
3. Pattern (J)		% deduction		
- no. of obstacles per quarter section	________	________		
- field size < 16 ha	________	________		
Pattern deduction		________	%x (a) = (c)	________
4. Erosion (E)		% deduction		
- estimated volume soil loss in gullies	________			
- years since reclamation	________			
- annual gully erosion	________	________		
Erosion deduction =	________	________	%x (a) = (d)	________

FINAL LANDSCAPE RATING (L) = (a) _____ -(b) _____ -(c) _____ -(d) _____ = _____

= ________ , ________
Class Subclass

Climate (C) Rating

1. Moisture component (A)   value   point deduction

- P-PE index   ________

A = 100 -   ________ = ________

2. Energy component (H)

- EGDD index   ________

H = 100 -   ________ = ________

FINAL CLIMATE RATING = LOWER OF A OR H (C) ________

= ________ , ________
Class   Subclass

FINAL RATING

index   factors

S = ________ or class ________, ________ ________

L = ________ or class ________, ________ ________

C = ________ or class ________, ________ ________

Class	S	L	C
	subclasses		
	____	____	____

Index	Class
80 - 100	1
60 - 79	2
45 - 59	3
30 - 44	4
20 - 29	5
10 - 19	6
0 - 9	7

APPENDIX

Explanations and Descriptive Techniques

In examining soils, you consider many factors and describe those which are relevant to the soil handling, management, or land use in question. This section focuses on the physical factors used in describing soils, especially those relating to disturbance and reclamation of lands. The first things you look for in inspecting an area are the landscape features including landform, topography, drainage, stoniness, vegetation patterns, land use and variations or irregularities in these. Next you stratify the landscape into different "areas" of similar "conditions" based on these foregoing features. Then you investigate the soils at a few apparently typical sites within each of these "areas" as well as any unusual spots.

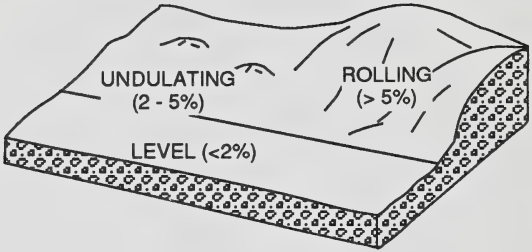
In a natural landscape, soils in similar settings tend to be alike, so a few well placed inspections (say 3 to 10) will enable you to describe the site and variability within it. In reclaimed areas, it is more difficult to identify or predict where the "typical" site is because soil conditions do not necessarily reflect a pattern, therefore, a grid or transect approach is normally used, and the number of inspection sites is increased. An exception may be where the reclamation procedure followed a specific pattern that is known, for example, depth of soil replacement or other handling practices, differing in strips or areas.

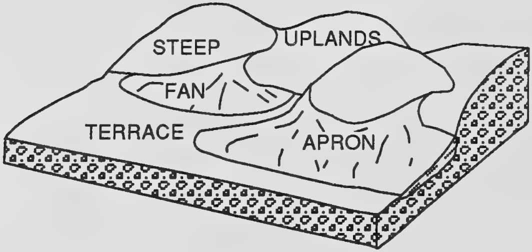
The following section outlines the main categories, standard terms and definitions or descriptions commonly used in making site descriptions.

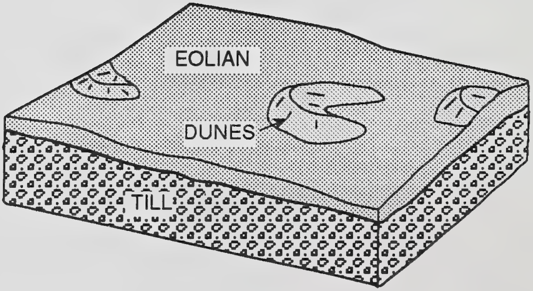
Landform Classification

Parent Material	Mode of Deposition	Recognizable Features	Landforms
M Morainal (till)	By melting ice	Heterogeneous mixture of boulders, sand, silt, and clay.	Till plains; moraines
F Fluvial and glaciolacustrine	By running water (e.g. river deposits)	Coarse textured; well rounded; sorted and often stratified	Alluvial fans; flood plains; outwash plains
L Lacustrine and glaciolacustrine	By running water into standing water (e.g. lake deposits)	Fine to medium textured; well rounded; sorted and often varved with occasional icerafted pebbles. Sand and gravel beach deposits.	Deltas; lacustrine clay plains; beaches
E Eolian	By winds.	Coarse silt to medium sand; very well rounded; very sorted; poorly compacted. Cross bedding	Dunes, plains
O Organic	In cool, wet depressions	Black, organic remains in various stages of decomposition	Bogs; swamps; muskegs, fens; marshes
C Colluvial	By direct gravity induced movement	Dependent on the nature of the material from which it was derived. Colluvium derived from bedrock typically contains angular, coarse fragments	Talus cones, rubbly colluvial blanket
S Softrock	Usually Cretaceous	Soft or weathered mudstones and siltstones, sometimes saline/sodic	Plains, ridges, knolls

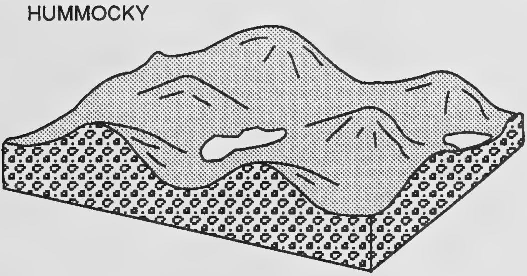
Illustrated Landforms

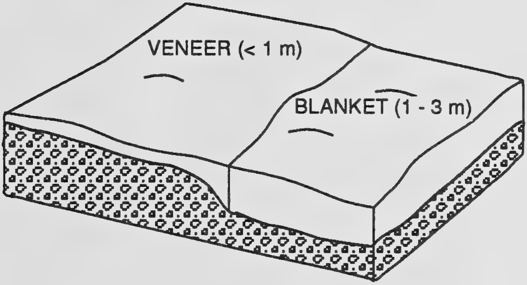


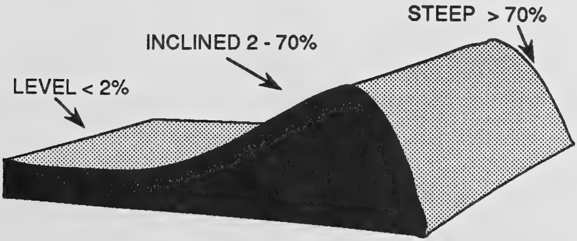




Illustrated Landforms



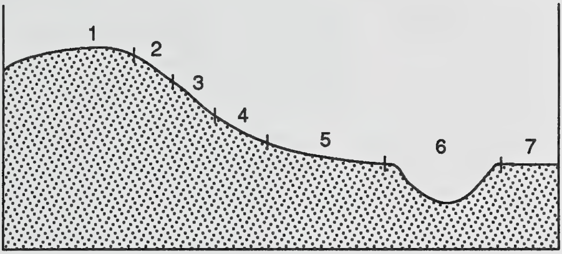




Topographic Classes

Class	Percent Slope	Degrees	Class Terminology
1	0-0.5	0	level
2	0.6-2	0.3-1.1	nearly level
3	3-5	> 1.1-3	very gentle slopes
4	6-9	> 3-5	gentle slopes
5	10-15	> 5-8.5	moderate slopes
6	16-30	> 8.5-16.5	strong slopes
7	31-45	> 16.5-24	very strong slopes
8	46-70	> 24-35	extreme slopes
9	71-100	> 35-45	steep slopes
10	> 100	> 45	very steep slopes

Slope Position



1. **Crest** - the upper most portion of a slope, shape usually convex in all directions with no distinct aspect.
2. **Upper slope** - the upper portion of the slope immediately below the crest, slope shape usually convex with a specific aspect.
3. **Middle slope** - the area of the slope between the upper and the lower slope where the slope shape is usually straight with a specific aspect.
4. **Lower slope** - the lower portion of the slope immediately above the toe, slope shape usually concave with a specific aspect.
5. **Toe** - the lower most portion of the slope immediately below the adjacent to the lower slope, slope shape concave grading rapidly to level with no distinct aspect.
6. **Depression** - any area that is concave in all directions, usually at the toe of the slope or within level topography.
7. **Level** - any level area excluding toe slopes, generally horizontal with no distinct aspect.

Soil Drainage Classes

Soil drainage classes are defined in terms of actual moisture content in excess of field moisture capacity, and the extent of the period during which such excess water is present in the plant root zone (C.D.A. 1974).

Rapidly drained (r) - soil moisture content seldom exceeds field capacity in any horizon, except immediately after the addition of water.

Well drained (w) - soil moisture content does not normally exceed field capacity in any horizon except possibly the C for a significant part of the year.

Moderately well drained (mw) - soil moisture in excess of field capacity remains for a small but significant period of the year.

Imperfectly drained (i) - soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year.

Poorly drained (p) - soil moisture in excess of field capacity remains in all horizons for a large part of the year.

Very poorly drained (vp) - free water remains at or within 30 cm of the surface most of the year.

Land Use Categories

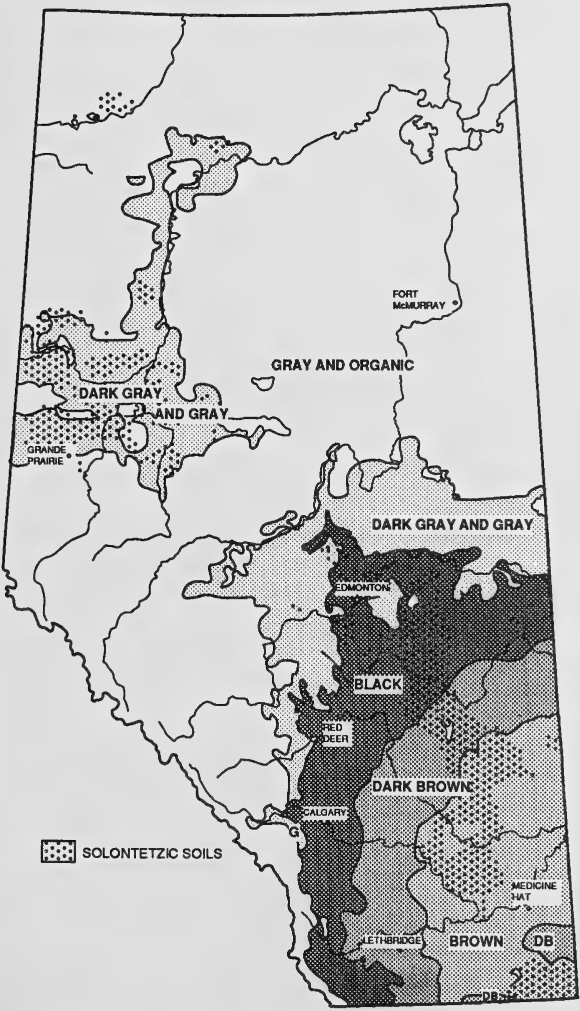
C	-	cultivated
H	-	hayland
IR	-	improved range
M	-	muskeg
NR	-	native range
P	-	pasture
W	-	wooded
WT	-	wetland

Soil Horizons

Soil forming processes result in the development of layers of soil with different characteristics called soil horizons. In disturbed soils these layers are usually not as obvious as in natural soils, or they may be mixed. A soil horizon is a layer of soil approximately parallel to the land surface. Soil horizons are separated from each other on the basis of colour, structure, consistence and texture as well as chemical, biological and mineralogical composition. Each soil horizon has its own characteristic features. A soil profile is a vertical section of soil extending through the soil horizons from the surface to the parent material. Natural soils have A, B and C horizons while matching layers for reclaimed soils are TS, topsoil; US, upper subsoil above 50 cm; LS, lower subsoil from 50 to 100 cm.

Horizon Nomenclature

Horizon	Description
L,F,H	organic horizons developed mainly from leaves, needles and twigs (litter layer)
Ah, Ahe, Ap	dark coloured, mineral, surface horizons, enriched with organic matter (p-man modified. eg. plow layer)
Ae	light gray coloured, leached mineral horizon that is low in organic matter and clay
AB	a transitional horizon from A to B
Bt	brownish subsurface horizon, enriched with clay that has been moved from the Ae horizon
Bnt	columnar, very hard, sodium enriched and clay enriched subsurface horizon
Bm	brownish subsurface horizon with only slight additions of iron, aluminum or clay
Bf, Bhf	reddish-brown subsurface horizon with significant accumulation of iron, aluminum and/or organic matter
Bg	horizons with gray gley colours or mottling or both, indicative of poor drainage
BC	transition horizon from B to C
C	relatively unweathered material from which soil profile has developed
Ck, Cca	a C horizon containing calcium and/or magnesium carbonates that will effervesce with dilute HCl, presence indicated by k; abundance by ca
A, B, or C with s, sa	a horizon with presence (s) or abundance (sa) of salts, salt crystals visible but will not effervesce with dilute HCl
Of, Om, Oh	organic horizons developed mainly from mosses and rushes. Poor drainage conditions. The state of decomposition is denoted by f - fribric, poorly decomposed; m - mesic, moderately decomposed; h - humic, well decomposed



Soil Zones of Alberta

KEY SOIL PROPERTIES

Soil Texture

There are numerous ways of hand texturing soils: they all take practice. Occasional checking with laboratory results is helpful.

Worm Method

- place a small amount of soil in the palm of the hand.
- slowly add water, kneading with fingers until smooth.
- try to roll soil into a 'worm'. Clay causes the soil particles to stick together. The more clay there is in the soil sample, the easier it is to form a 'worm' which will hold together well.
- if the soil is very sticky and makes a very strong 'worm', the texture is heavy clay.
- if the soil is sticky, some grit can be felt in the sample indicating the presence of some sand, and a good 'worm' is made, then the texture is clay.
- if the soil is only slightly sticky and only a fair 'worm' is made which tends to crack and break when formed into a loop, then the texture is clay loam or sandy clay loam.
- if the soil is not sticky and only a poor or no 'worm' can be made which cannot be formed into a loop, then the texture could be one of the following classes; silt, silt loam, sandy loam, loamy sand or sand. The amount of sand and/or silt will have to determined by 'hand feel' in order to place the soil in one of these textural classes. Silty soil will have a very greasy slick (soapy) feel.

Feel Tests

Graininess test - Soil is rubbed between thumb and finger to assess the % sand. Sand feels grainy.

Dry feel test - For soil with >50% sand. Soil is rubbed in the palm of the hand to dry it and to separate and estimate the size of the individual sand particles. The sand particles are then allowed to fall out of the hand and the amount of fine material remaining is noted.

Stickiness test - Soil is wetted and compressed between the thumb and forefinger. Degree of stickiness is determined by noting how strongly it adheres to the thumb and forefinger upon release of pressure and how much it stretches.

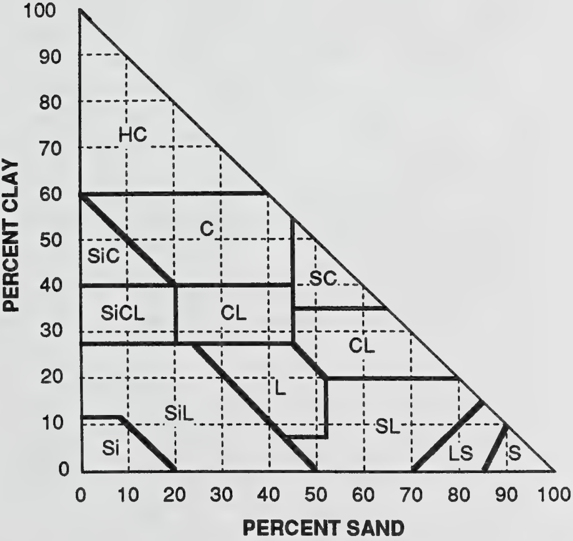
Moist cast test - Compress some moist soil by clenching it in to your hand. If the soil holds together (i.e. forms a cast), then test the strength of the cast by tossing it from hand to hand. The more durable it is, the more clay is present.

Shine test - A small amount of moderately dry soil is rolled into a ball and rubbed once or twice against a hard, smooth object such as a knife blade or thumb nail. A shine on the ball indicates clay in the soil.

Comparison of Different Soil Texture Testing Methods

Texture Class	Feel Test	Moist Cast Test	Worm Test	Shine Test
SAND	grainy	no cast	none	
LOAMY SAND	grainy, slightly floury	very weak cast. no handling	none	
SILTY SAND	grainy, moderately floury	weak cast. no handling	almost flakes if sand portion is vfs or fs	
SANDY LOAM	grainy, moderately floury	weak cast. allows careful handling	barely ribbons (1.5 - 2.5 cm)	
LOAM	soft, smooth, slight graininess	good cast. readily handled	thick and very short (< 2.5 cm)	
SILT LOAM	floury, slightly grainy	weak cast. allows careful handling	flakes rather than ribbons	
SILT	very floury	weak cast. allows careful handling	flakes rather than ribbons	
SANDY CLAY LOAM	very grainy	moderate cast	short and thick (2.5 - 5 cm)	slightly shiny
CLAY LOAM	moderate graininess	strong cast	fairly thin. breaks rapidly. barely supports own weight	slightly shiny
SILTY CLAY LOAM	smooth and floury	strong cast	fairly thin. breaks rapidly. barely supports own weight	slightly shiny
SANDY CLAY	substantial graininess	strong cast	thin, fairly long (5 - 7.5 cm). holds own weight	moderately shiny
SILTY CLAY	smooth	very strong cast	thin, fairly long (5 - 7.5 cm). holds own weight	moderately shiny
CLAY	smooth	very strong cast	very thin. very long (< 7.5 cm)	very shiny

Texture Triangle



Soil Structure (Aggregation)

Soil structure refers to the grouping or arrangement of the soil particles (sand, silt and clay) into larger units or aggregates which give the soil material a structure. In topsoil, organic matter acts like a 'glue' to hold soil aggregates together. Aggregation may be determined by dropping a mass of soil (spade full) one metre onto a hard surface (plywood), and visually estimating the dominant size category of aggregates or clods. Size categories for subsoil are <2 cm, 2 to 10 cm, 10 to 30 cm and >30 cm. Kinds of soil structure based on the shape of the aggregates are:

Granular structure is characterized by small (<10 mm) rounded aggregates (peds). This is typical of topsoils.

Platy structure occurs when particles are arranged in horizontal planes. Thickness of plates is about 1 to 5 mm. This is typical of Ae horizons.

Subangular blocky structure occurs when soil aggregates are subrounded or subrectangular. Size is normally 0.5- 5 cm mm in diameter. This structure is common in B horizons.

Blocky structure is characterized by angular, rectangular aggregates. This occurs in well developed Bt and Bnt horizons.

Prismatic structure occurs when particles are arranged around a vertical axis, having sharp well-defined vertical faces.

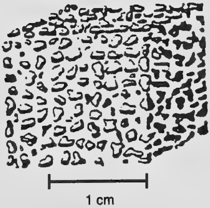
Columnar structure is characterized by columns with round or flat tops and well defined vertical faces. This is typical of Bnt horizons.

Single grain structure is characterized by a loose, incoherent mass of individual particles as in sands.

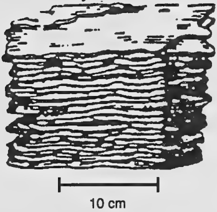
Massive structure occurs as a coherent mass showing no evidence of any distinct arrangement of soil particles.

Illustrated Structure

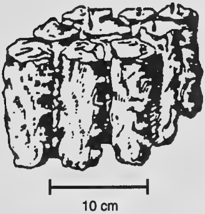
Granular



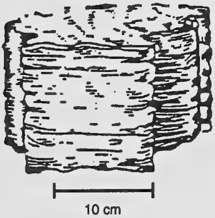
Platy



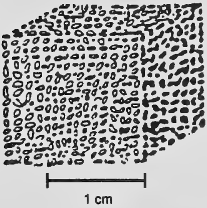
Prismatic



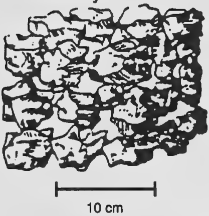
Massive



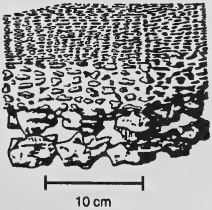
Single Grain



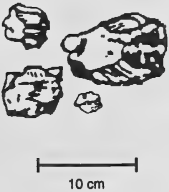
Blocky



Compacted (layered)



Aggregate Sizes



Dry Soil Consistence

Loose - The soil falls apart into individual grains.

Soft - The soil is weakly coherent and fragile, and breaks to a powder or individual grains under very slight pressure.

Slightly hard - The soil is weakly resistant to pressure and easily crushed between the thumb and forefinger.

Hard - The soil is moderately resistant to pressure; without considerable pressure it cannot be crushed between the thumb and forefinger but can be crushed in the hands without difficulty.

Very hard - The soil is very resistant to pressure; it can be crushed between the hands only with difficulty.

Extremely hard - The soil is extremely resistant to pressure and cannot be crushed between the hands.

Moist Soil Consistence

Loose - The soil falls apart into individual grains.

Very friable - The soil is crushed under very gentle pressure, and coheres when pressed together.

Friable - The soil is crushed under gentle to moderate pressure between the thumb and the forefinger, and coheres when pressed together.

Firm - The soil is crushed under moderate pressure between the thumb and forefinger, but resistance is clearly noticeable.

Very firm - The soil can be crushed between the thumb and forefinger, but strong pressure is required.

Extremely firm - The soil cannot be crushed between the thumb and forefinger.

Soil Compaction

Soil compaction can result in:

- poor root penetration;
- difficult cultivation;
- poor seedbed preparation;
- increased soil strength;
- reduced water infiltration;
- increased surface water runoff; and
- decreased soil porosity.

Soil compaction can be determined indirectly through the use of penetrometers. Soil strength is measured by determining the resistance of soil to the penetration tip of the penetrometer and is greatly by soil moisture content and density. Generally:

- in non-compacted soils, penetrometers penetrate easily;
- in moderately compacted soils, penetrometers penetrate with moderate effort; and;
- in very compacted soils, penetrometers penetrate with difficulty.

Because penetration resistance is affected to a large degree by the soil moisture content, soils must be at similar moisture contents.

Common relationships between kind of horizon, structure, consistence, texture and bulk density

Kind of Horizon	Common Structure	Common Consistence dry/moist
Ah	granular	sl. hard friable
Ae	platy, massive	soft, sl. hard friable
Ap (> 1% OM)	granular	friable
Ap (< 1% OM)	massive friable-firm	soft-hard
Bm	subangular prismatic	sl. hard friable-firm
Btj	blocky prismatic	hard firm
Bt	blocky	hard-v. hard firm-v. firm
Btnj	blocky- columnar	v. hard v. firm
Bnt	columnar- blocky	ex. hard ex. firm
Bn	columnar- massive	ex. hard ex. firm
Bf	wk. granular massive	sl. firm firable

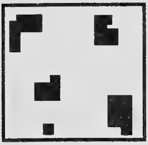
Soil Density

Kind of Horizon	S LS	SL	L	SiL CL	SiCL SiC	C
	g/cm^3					
Ah	1.30	1.20	1.15	1.10	1.00	0.95
Ae	1.45	1.40	1.35	1.30	1.30	--
Ap (> 1% OM)	1.40	1.35	1.25	1.20	1.10	1.05
Ap (< 1% OM)	1.40	1.40	1.40	1.35	1.30	1.25
Bm	1.50	1.45	1.40	1.40	1.35	1.30
Btj	1.50	1.50	1.45	1.45	1.45	1.40
Bt	--	1.55	1.55	1.60	1.60	1.50
Btnj	--	1.50	1.50	1.50	1.50	1.45
Bnt	--	1360	1.60	1.65	1.60	1.50
Bn	--	--	1.65	1.65	1.60	1.50
Bf	1.50	1.45	1.35	1.35	--	--

Soil Salinity Indicators

Salinity EC (dS/m)	Common Features
2	- no apparent signs - affects sensitive crops
4	- presence of foxtail - some white specks on soil surface - crop growth affected to some extent
8	- plants restricted to salt tolerant species (e.g., Kochia) - white salt crusts common - crops strongly affected
10	- plants restricted to species such as red saphire - salt crust and salts throughout profile - little or no crop growth

Area Percent Charts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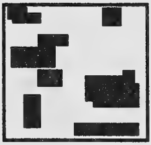
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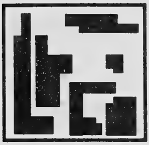
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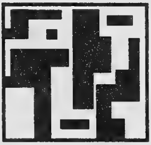
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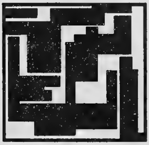
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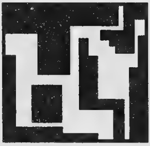
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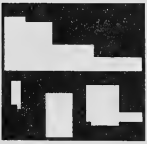
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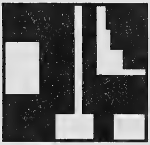
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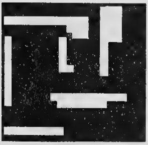
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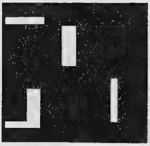
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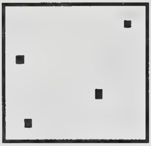
Area Percent Charts



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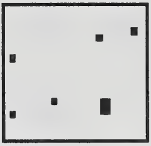

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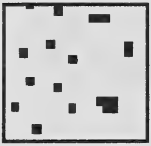

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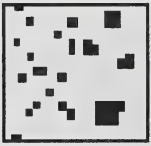

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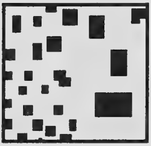

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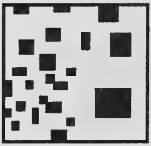

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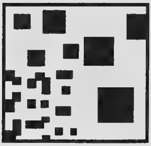

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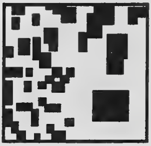

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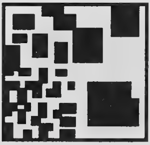

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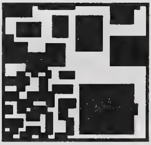

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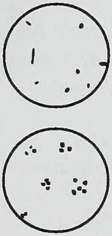
Area Percent Charts



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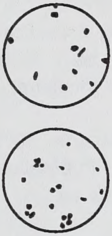

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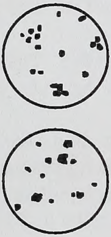

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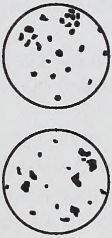

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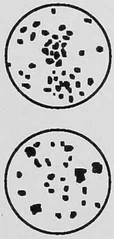

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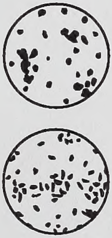

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